

INTENSIVELY MONITORED RESTORATION PROJECT-BRIDGE CREEK

We propose a pilot restoration project along 4 km of Bridge Creek, sufficient to cause a population-level impact to the steelhead that utilize the system. We will monitor the results, treating Bridge Creek as an intensively monitored watershed/restoration site. This is consistent with the purposes of IMWs, one of which is to test the impacts of restoration projects with the goal of detecting population-level effects on targeted species (Bilby et al 2004, PNAMP, 2005). Monitoring will be designed to gather responses to the manipulation as well as covariates unaffected by the manipulation. The results will be analyzed and used to inform whether the restoration action was beneficial to the population (the original goal of the Biological Opinion) while revealing important causal mechanisms.

The Bridge Creek subbasin is a 710 km² watershed draining directly into the lower John Day River. Bridge Creek and its tributaries are utilized by a run of Middle Columbia steelhead that are part of the ecologically distinct Lower John Day population which occupies the lower, drier Columbia Plateau ecoregion within the John Day subbasin and are listed under the Endangered Species Act (CBMRC 2005, p. 75). The John Day Subbasin Plan (JDSP) has designated Bridge Creek as a priority watershed for restoration because its salmonid production and abundance potential is high (CBMRC 2005, pp. 83, 249). The JDSP also identifies habitat quantity, temperature, sediment load, habitat diversity and flow as limiting factors in Bridge Creek (CBMRC 2005, p.83).

Analysis of the John Day and other subbasins in the interior Columbia River basin suggest that incision is a widespread phenomenon affecting as much as half of all the fish bearing streams in a watershed (Beechie and Pollock, unpublished data). Historical records suggest that Bridge Creek and nearby watershed incised deeply in the early 1900s, shortly after Europeans began to settle the area. (Buckley 1992, Peacock 1994) The mainstem incision depth in Bridge Creek typically ranges from 1-3 m, sufficient to disconnect the stream from the former floodplain (Figure 1). This has resulted in the lowering of floodplain water tables, the loss of off-channel habitat and riparian forest and a general simplification of stream habitat (Figure 1, Elmore et al. 1994). Stream temperatures in the summer frequently exceed 27 °C, and late summer streamflows are less than 5 cfs (Anna Smith BLM Hydrologist, personal communication). Not surprisingly, it is on the 303(d) list of temperature impaired streams (CBMRC, 2005 p. 40). Due to the erosive nature of some of the geologies and in particular, the large number of incised, failing stream banks, sediment loads are high in Bridge Creek, especially during peak flow events. Annual suspended sediment loads may exceed 19,000 m³ (Pollock and Beechie, unpublished data).

The purpose of the project is to engage in watershed restoration at a scale sufficient to cause a detectable, population-level impact to the steelhead and that utilize this watershed. This project proposes to take a process-based approach to restoration of Bridge Creek to cause aggradation of approximately 4 km of incised mainstem stream bed and lower tributary reaches. Such aggradation should raise floodplain water tables and lead to increased summer streamflows, decreased stream temperatures, a narrower and more sinuous stream channel, and a vastly expanded riparian forest. Thus we propose to restore one process (aggradation), which in turn will trigger a series of positive feedback loops that restore other biological and physical processes that maintain stream ecosystems. We expect restored reaches will potentially increase steelhead rearing capacity approximately 30 fold or 13,000 steelhead parr. Using available parr and smolt survival estimates for the John Day River, we calculate that the project will result in an additional 79 steelhead adult spawners in Bridge Creek. The existing population is poorly documented because spawner surveys are infrequent, but based on the limited, available spawner survey data from ODFW, which is the best data we have, we estimate that our efforts would roughly double the current population.

Proposed actions

Presently, aggradation is already occurring behind reaches where the small, existing beaver population has constructed dams. Some of these dams have backfilled completely with sediment, allowing for riparian vegetation such as willows to colonize (Figure 2) and create a stable, elevated

stream bed and floodplain. High sediment loads and rapid riparian colonization in this system has resulted in a rapid aggradation process (<10 yr). This process has locally elevated the stream bed by as much as 1.5 m in some places, but more typically by less than 0.5 m. Unfortunately, many of the beaver dams fail before the upstream sediment wedge and dam can be stabilized by riparian vegetation. Dams appear to fail primarily because of the lack of large diameter woody vegetation (e.g. willow and cottonwood stems) to provide sufficient strength to withstand high flows (Michael Pollock, personal observation).

We propose 3 restoration strategies that mimic (strong) beaver dams to accelerate aggradation processes, which include: (1) Beaver dam assisting devices: insertion of vertical posts or poles across the incised trench to provide key members for beaver to build dams off of (Figure 3); (2) construction of small diameter log bundles placed perpendicular to the stream in a series of steps (Figure 4); and construction of a series of rock steps. Each strategy should result in elevated water tables sufficient to expand the riparian gallery forests and thus create a long-term supply of structural material for the construction and maintenance of more beaver dams. All of these structures should become “invisible” in a relatively short time period as aggradation and vegetative colonization occurs. The three strategies range between the relatively low cost option of enhancing habitat so that beaver will build stable dams versus the higher cost option of actually constructing sediment aggrading structures. We have identified three general areas along the mainstem of Bridge Creek totaling approximately 4 km in length where criteria is appropriate and the likelihood of success is high (Figure 5). Criteria selection included stream gradient, incision depth, floodplain width and presence of upstream sediment supplies.

Post-pile fence. This strategy is simple in concept, and lowest in cost. A series of posts or poles are pounded into the bed substrate perpendicular to the flow of the stream (Figure 3), preferably near natural constrictions with low-gradient upstream reaches. These posts provide key structural support that can then be used by beaver to build durable dams better able to withstand high flow events until the area behind the dam can backfill with sediment and be colonized by woody riparian vegetation. A series of posts lines will be placed in close proximity to mimic typical frequencies and heights of beaver dams. An idealized beaver dam sequence might be a primary dam 1-1.5 m high with a smaller 0.5-1 m dam 20-50 m downstream of the primary dam and 2-3 intermediate-sized (0.5-1 m) dams upstream of the primary dam, and spaced perhaps 30-100 m apart, depending on stream gradient, creating a series of connected pools. We will also provide piles of cottonwood and willow branches for beaver during the dam-building season (summer) to supplement food and building material. We will work with ODFW to relocate nuisance beaver (of which there is a steady supply) to our sites. Such a strategy has been successfully employed elsewhere to trap sediment in streams (Scheffer 1938, Apple 1983).

Bundled log steps. This strategy employs bundles of small diameter (30 cm) poles to create a series of steps sufficient to raise the stream bed to the desired height, usually 1-2 m (Figure 4), to raise the nearstream water table close to the level (< 0.5 m) of the floodplain. The structure is designed such that it will be covered with vegetation and sediment, particularly once the area behind it backfills with sediment. Riparian plantings (willow and cottonwood staking) will be used to aid in the “visual recovery” of the project. Thus within a relatively short time frame (< 10 yrs) the project structure will be invisible, and in a longitudinal profile of the stream will appear as a locally steepened section (Figure 4). These structures are designed to mimic (very strong) beaver dams in terms of size and function. These are much higher in cost than the post-pile fences, and therefore will be limited to fewer locations.

Rock steps. This strategy employs the use of rock to create a series of steps that will cause aggradation, similar in design to the bundled log steps (see Figure 4). Basalt rock is a common feature throughout much of the watershed, so indigenous materials can be used.

Expected impacts on *O. mykiss*.

We expect the restoration actions implemented will restore floodplain processes that will result in increased baseflow, lower summer temperatures, decreased sediment loads and greater habitat complexity

such as more off-channel habitat, more riparian vegetation, and more frequent and deeper pools. These increases in habitat quality and quantity should increase the carrying capacity of the system. Greater habitat complexity also provides refuge from predation, interference competition, and high velocity current. The expected decrease in temperature should also reduce predation by warm water species such as the exotic smallmouth bass found in this system either through thermal displacement or lowering energetic demand. Decreased temperatures should also provide a thermal environment closer to the energetic optima of *O. mykiss*, resulting in an increase in growth rates. In addition, allocthonous inputs should increase with an increase in floodplain connectivity and riparian vegetation, boosting primary and secondary production, and increasing growth rates of fishes. Decreases in energetic expenditures (e.g. temperature and refuge, increases in energetic inputs (e.g. production), and decreases in mortality (e.g. predation) are expected to increase survival and production. Decreased sedimentation should lead to a decrease in gravel and cobble embeddeness, providing increases in suitable spawning gravels, and habitat complexity for periphyton, benthic invertebrates, and parr. Egg survival is also expected to increase as entombment of eggs by sediments is decreased.

To evaluate whether fish are responding to changes in habitat as expected we will monitor several response variables: 1) Spatial distribution (juvenile steelhead, and other fish species); (2) smolts per redd or per spawner (steelhead); (3) migratory timing and size (steelhead parr and smolts); (4) population abundance (steelhead parr, smolts, and other fish species); (5) parr-to-smolt survival (steelhead); (6) smolt-to-adult ratio (SAR- steelhead); and (7) recruiting adults (R/S- steelhead).

The experimental and monitoring program will be designed to address the hypotheses whether changes in these response variables are a result of the restoration actions, after accounting for the number of spawners, natural disturbances, climate indicators, and habitat conditions not-impacted by the actions (i.e. covariates).

Experimental Design

The experimental design attempts to maximize our ability to detect responses as a function of the restoration action. We plan to do this by comparing a time series of responses prior to the manipulation to a series after the manipulation. Intervention Analysis (IA) have been used for these types of comparisons (Box and Tiao 1975, Steward-Oaten 1986, Carpenter et al. 1989). A Before-After-Control-Impact (BACI) approach is an IA with non-manipulated sites used as a covariate, thus the “controls” are used to reduce variation but are not used to measure it as do true experimental controls (Steward-Oaten and Bence 2001). Basically, the difference between the manipulated and the control responses are calculated for every sample event and these are averaged for the pre- and post-treatment periods, or $\bar{D}(\text{PRE})$ and $\bar{D}(\text{POST})$, respectively. The test statistic is $|\bar{D}(\text{PRE}) - \bar{D}(\text{POST})|$ and is compared to a theoretical distribution (e.g. BACI; Steward-Oaten et al. 1986) or a distribution of random permutations of the observed sequence of treatment and control differences (e.g. a Randomized Intervention Analysis; Carpenter et al. 1989). The latter of these is not constrained by the assumptions of parametric statistics (for a comparison of BACI and RIA see Cloutman and Jackson 2003). By evaluating the difference in treatment and control, shared characteristics (e.g. climatic conditions, geology and vegetation types, and monitoring crews) tend to cancel out. Thus, the benefit of a control as a covariate, capturing multiple parameters, becomes more apparent. If treatment and control watersheds differ substantially in a characteristic as to swamp the effect of the treatment then these can be used as covariates to aid in partitioning these sources of variability from the differences caused by the treatment. Techniques are available to select useful covariates from a list of potential covariates measured throughout the study period (Milliken and Johnson 2001, Kershner et al. 2004). Further refinement to statistical models can account for temporal autocorrelations, cyclic effects, and gradient effects (Draper 1984, Steward-Oaten and Bence 2001).

We describe what we believe is a powerful design to detect the impacts of these restoration projects on steelhead, *O. mykiss*. Ultimately, everything describe below would be implemented, however, reality may prove otherwise. Because of the scale and complexity of the system we are proposing to study, we view the gathering of pre-treatment data as attempt to implement this plan fully and as a scoping process necessary to determine what is and is not feasible. Potential limitations include denied

permission by land owners, the ability to capture enough juvenile *O. mykiss* to PIT tag, natural disturbances (e.g. flood events or debris flows), vandalism, and other unforeseen events.

Depending on feasibility, the experimental approach will be implemented in the Bridge Creek study over multiple scales: the watershed, subwatershed, and reach scales (Figure 6). At the watershed scale, Bridge Creek will be compared to nearby Murderer's Creek, where ongoing monitoring of steelhead populations is already occurring. Within Bridge Creek, comparisons will be made between Bear Creek, Gable Creek and the mainstem. Within the mainstem of Bridge Creek comparisons will be made between control and manipulated reaches, separated by enough distance to reduce movement between reaches by parr.

Habitat surveys will also be collected in the same areas as the fish surveys (see below). This information will be used in conjunction with LiDAR information already collected to describe physically distinct reaches, as has been done to define sentinel reaches in the South Fork John Day IMW (Bouwes 2005). This will allow us to better pair control and treatment reaches for this and further experimental designs. A minimum of 6 reaches, 3 treated (manipulated) and 3 untreated (control) reaches, would need to be defined in the mainstem Bridge Creek. More reaches may be defined to provide more control reaches to bracket treatment conditions or to conduct other specific research projects attempting maximize contrast.

Although this hierarchical design may appear redundant, we will attempt this approach for several reasons. First, by including multiple controls at different scales, we are protecting against the possibility that something could go wrong with the one control approach, such as a large scale disturbance. Second, we are uncertain to the degree restoration may impact downstream reaches. Although a comparison of multiple reaches may be more powerful because of higher replicability and the ability to accurately describe a reach versus a watershed or subwatershed, these sites may not be independent from each other depending on the degree of movement by *O. mykiss*, and the degree to which physical impacts from treated reaches propagate into the next study reach. Third, hierarchical models such as structural equation modeling, may be able to capture small scale mechanistic relationships and how larger scale process form the template for these processes (Shipley 2005). This study will provide the information to parameterize such models. A better understanding of the ecological processes that act across scales to ultimately impact fish populations advances fish management (Fausch et al. 2002). Fourth, we are also evaluating the degree of variability and statistical power associated with each scale. This will provide insight into the scale at which future restoration actions should be monitored. This hierarchical design will also lend itself to the testing and development of causal relationships pursued in monitoring and research programs currently being implemented in the John Day RME pilot program.

Monitoring Design

Steelhead monitoring. After the experimental design has been determined, implementation monitoring (monitoring to ensure the restoration action is still in place) and effectiveness monitoring programs need to be designed. This will likely include a combination of fixed and probabilistic randomized sample sites (e.g. EMAP approach), pre- and post-manipulation in control and treatment watersheds. Fixed sites will reveal responses more quickly than randomized sites (Roper et al. 2002), but will likely not detect some responses such as increases in juvenile distribution. A mechanistic understanding of how restoration actions influence habitat and fish will help determine where fixed samples sites will be located. In some watersheds or reaches, whole census can be conducted negating the need for a design to select sample sites. Described below is the general monitoring program we will take to estimate before and after treatment fish responses in the control and treatment areas across multiple scales for each response variable. We will monitor several life-stages throughout the study areas, including parr (age 0 to pre-smolt which range in age from 1-4 yrs old), smolts, and adults.

This study will take advantage of recent advances in PIT tag technology, including the use of extended length PIT tag detectors that can be deployed to obtain nearly complete detection efficiency of tagged fish that pass through the antennas. The placement of PIT tag detectors between distinct reaches which include treated and untreated reaches. It is unclear how many parr can be captured and PIT tagged

in the different areas. Up to 3,000 tagged fish per watershed to provide watershed specific SAR estimates (I need to do a quick estimate of this xx). PIT tag antennas will document the amount of independence of reaches on fish distribution, habitat use, growth, and parr-to-smolt survival. In addition, the movement information will describe the importance of the potomandromous (seasonal movement between mainstem and tributaries) life history strategy as observed in the South Fork of the John Day IMW. This strategy is thought to occur because of an interaction between behavioral thermoregulation and density dependent interactions, where a percentage of the population uses cooler tributaries in the summer, migrates out in the fall to rear in the warmer mainstem John Day, and potentially returns to the tributaries as mainstem temperatures become too warm in the summer (Li et al 2005?? Reference something like their progress report). The use of tributaries for thermoregulation is a life-history strategy for steelhead that requires further investigation (CBMRC 2005, Tim Unterwiegner and Jim Ruzycki of ODFW, personal communication).

Parr abundance and distribution will be estimated through a combination of snorkeling surveys, snorkel-herding and electro-herding (electroshocker set to a low setting that is irritating but will not stun) into bag seines. Snorkel- and electro-herding will be used to capture fish to PIT tag as well as to calibrate snorkel surveys that are used by ODFW. These methods have been calibrated in the South Fork John Day IMW (Bouwes 2005). A census using snorkel/herd-seining surveys may be conducted over the entire study area. In some areas these surveys will not be logistically feasible, such as in beaver ponds where disturbance of sediments will preclude visual estimates, or in shallow waters that cannot be reasonably observed. In such instances, 3-pass electroshocking or mark-recapture Peterson abundance estimates will be conducted for each habitat unit. Surveys will be conducted at the beginning and the end of the summer field season. Habitat surveys will be conducted at these sites as well. Changes in fish density will be used to assess changes in habitat quality, with the assumption that fish select for higher quality habitat as a means to increase fitness. These surveys can be used to address reach scale comparisons or rolled up to assess larger scale comparisons. Further sampling may be done to capture more fish to increase the sample size of PIT tagged fish.

A redd census and carcass survey will also be conducted in Bridge Creek, Bear Creek and Gable Creek. As adults begin to return from the first cohorts of PIT tagged juveniles, carcasses will also be scanned for PIT tags. In addition, fixed reaches and ten 1 km long reaches selected in a random probabilistic design will be visited every two weeks throughout the season to quantify cumulative redd counts at each site, as is done for the ODFW steelhead surveys.

The number of smolts leaving and adults entering a watershed or subwatershed will be compared in this experiment as this gets to the most direct measure of interest, freshwater production or smolts per spawner. A removable two-way trap will capture outmigrating juveniles and incoming adults. The trap will be deployed daily to once a week and checked the next day. PIT tag antennas will be deployed above the traps to describe trap efficiency. The ratio of tagged to untagged fish may remain rather constant negating the need to deploy the trap on daily basis (this is currently being evaluated in the South Fork John Day IMW). All outmigrating juveniles will be scanned using a hand-held PIT tag detector or tagged if no tag is detected for further survival estimates (SARs). These traps will be operated during the migration seasons when possible. The traps will be used to capture adults migrating upstream to the spawning grounds. Adults will be measured, aged, sexed and scanned for tags as well during the spawning season. This information will be used to estimate recruits per spawner or overall life-cycle survival.

Cormack-Jolly-Seber (CJS) models of mark-recaptured PIT tag fish will be used to estimate seasonal parr survival, parr-to-smolt survival, smolt reach survival in the mainstem John Day and Columbia River, and smolt-to-adult survival between reaches, subwatersheds and watersheds. PIT tag detected at PIT tag antennas in the study watersheds, smolt and adult traps, and John Day and Bonneville dams on the Columbia River will be used to make these estimates. Multiple CJS type models can be compared to evaluate influence other covariates such as; time at release, size, number of times recaptured, and habitat features on survival rates (White et al. xx).

The size, timing, and age of out-migration smolts may provide information about changes to habitat quality. Length and weights of parr captured for tagging will be measured. Juveniles recaptured at

the traps or in later juvenile surveys will also be measured to describe a change in biomass or growth. Growth rates will then be compared between reaches, subwatersheds, and watersheds throughout the study. Bioenergetics model can be used to further partition these changes in growth to changes in temperature and prey production. Growth rates and other information are a more proximate response to habitat quality than measures of survival allowing for a finer resolution evaluation of the impacts of these restoration actions on juvenile salmonids. Also, changes in the amount of time spent rearing in the different study areas will also provide us a more mechanistic understanding of impacts of restoration to this population.

Habitat monitoring –LiDAR and 3-band digital aerial photography remote sensing has already been conducted for Bridge Creek and Murderer’s Creeks. When analyzed these data will provide baseline data on stream and riparian habitat conditions within the restored and control reaches. Using these data, habitat parameters that will be quantified within the restored and control reaches include: aerial extent of riparian vegetation, sorted by dominant vegetation type (e.g. willows, cottonwoods, emergent graminoids), stream geomorphology, including cross-section geometry, planform sinuosity and longitudinal gradient profile, and the location and size of beaver dams. Our goal is to repeat these remote sensing surveys over the study area every 3 yrs after completion of the project to measure changes in habitat quality and quantity. Because LiDAR does not easily penetrate water, we will also measure and monument stream cross-sections at the restored and control sites so as to provide data on aggradation rates and volumes behind the structures relative to control sites, as well as providing detailed information on changes in the channel cross-section geometry. Additionally, in FY 2006 we (NOAA Fisheries) will be installing water level monitoring well fields along the proposed restoration and control sites to measure the anticipated changes in floodplain groundwater levels upstream and downstream of the aggradational structures, including “control” locations where beaver dams already exist. Automatic water level recorders/temperature monitors will be installed in the wells. In FY 2006 we will also install temperature data loggers within the restored and control reaches, which will remain in place before, during and after completion of the restoration project.

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Figure legends.

Figure 1. A typical incised reach of Bridge Creek at high flow during spring runoff. Incision depth in this reach is 1.5-2 m. Note the high suspended sediment load.

Figure 2. View of an aggraded reach upstream of a 1.5 m high beaver dam on Bridge Creek, Oregon. The pond has almost completely backfilled with (approximately 7500 m³) of sediment. Willows, cattails and other riparian vegetation have colonized the new surface. Additionally, willows have recently replaced sagebrush on the adjacent terrace where water tables have risen to within 0.5 m of the surface. The dam is just beyond the patch of open water in the upper left of photograph.

Figure 3. Schematic of a post-pile fence design to facilitate beaver dam construction-a "soft engineering" approach for causing aggradation of an incised stream bed.

Figure 4. Schematic of an idealized bundled-log complex dam-a "soft engineering" approach for causing aggradation of an incised stream bed.

Figure 5. Map of Bridge Creek showing approximate locations of proposed restoration and control reaches and proposed PIT tag detectors and smolt traps. Smolt and adult traps will measure watershed and subwatershed abundances, and PIT tag detectors will be used to describe movement between reaches and survival information.

Figure 1.



Figure 2.



Figure 3.

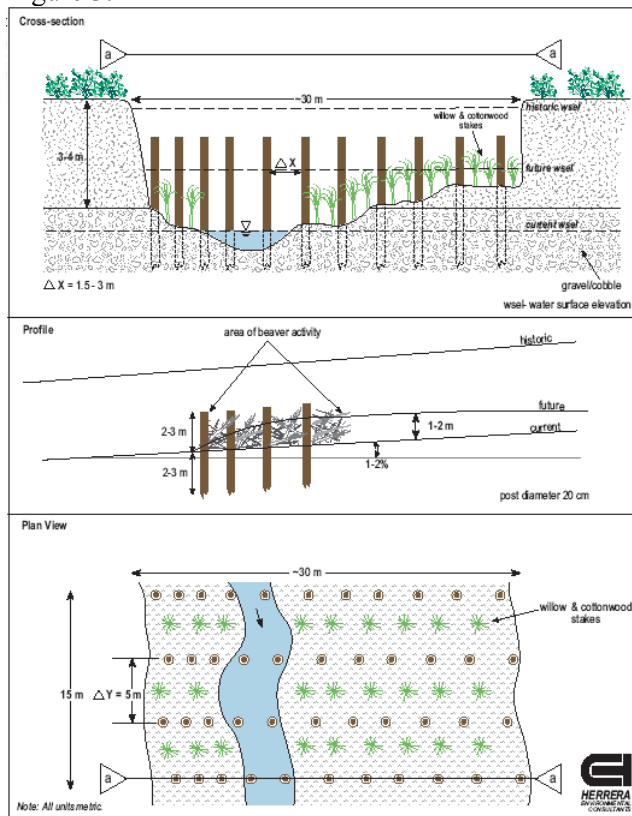


Figure 4.

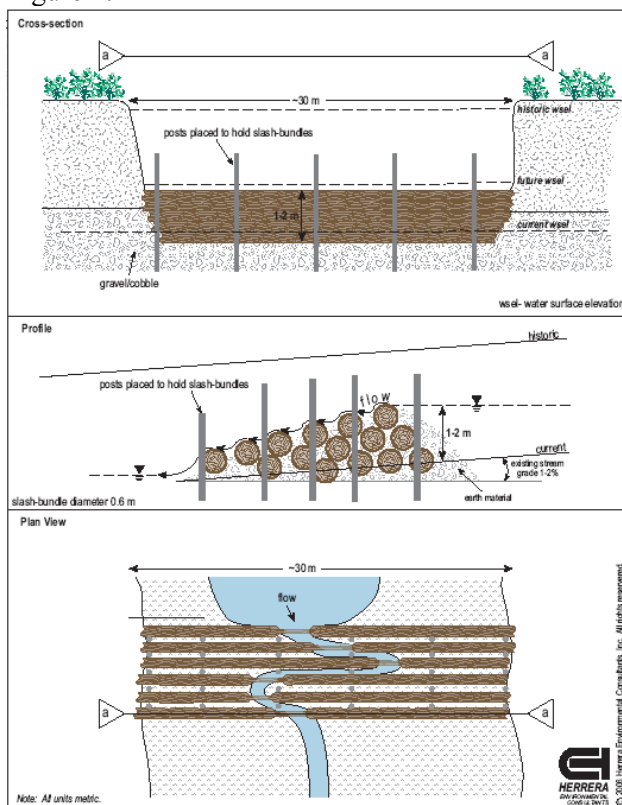


Figure 5.
To be completed Monday.

Notes (to be deleted) xx NHD stream reach code-ask carol